DISSERTATION

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Wideband Train-to-Train Channel Model

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Abstract

Due to the continuous growth of passenger and freight transport and the simultaneous effort to reduce global greenhouse gas emissions, many countries are relying on railways. To increase efficiency and to ensure safety, novel operational concepts such as virtual coupling or autonomously driving trains are being developed. These concepts require reliable and low-latency communication. Future communication standards will improve existing railway communications and enable highly reliable and low-latency train-to-train (T2T) communication. In order to achieve the required reliability, the propagation conditions must be taken into account when designing the radio systems. For safety critical applications, the investigation of correlated error events is of great interest. Hence, the channel model has to reflect the time-variant behaviour of the propagation channel. Suitable channel models for T2T communications were not available until now.

In this dissertation a wideband T2T channel model is proposed. The channel model is based on C-band measurements. For this reason, the worldwide first wideband T2T channel sounding measurement campaign was conducted. Due to the changing environment and the moving transmitter and moving receiver the propagation channel is shown to exhibit non-wide-sense stationary uncorrelated scattering. The time-frequency-variant measurement data is analysed, the quasi-stationarity region is evaluated and the time-variant spreading function is derived. Based on the spreading function stochastic channel parameters for typical railway environments are estimated. Pronounced multipath components are isolated, tracked and assigned to elements along the railway track. A new metric called scattering loss is introduced to describe the influence of an element on the fading of the multipath component.

To reflect the time-variant behaviour of the channel and the typical geometry of railway environments a geometry-based stochastic channel model (GSCM) for T2T communications is introduced. The GSCM considers all relevant propagation phenomena and various railway manoeuvres. The GSCM is parametrized for an open field and a hilly terrain with cutting environment, and validated against measurement data. The quality of the channel model is accessed by qualitative and quantitative methods and shows an excellent representation or the propagation conditions for T2T communications in typical railway environments. This T2T GSCM is now available for the development of future railway communication standards.